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ACTIVITY BUDGETS OF SUMMER TANAGERS DURING SPRING MIGRATORY STOPOVER

DAVID A. ABORN[1,2,3] AND FRANK R. MOORE[1]

ABSTRACT.—We radio-tracked Summer Tanagers (*Piranga rubra*) at a Gulf coast stopover site to study en route activity budgets. Tanagers were inactive a majority of the time, with scanning, foraging, and preening being the next most commonly observed activities. When foraging, tanagers primarily used sallying to capture a variety of insect prey. Possible explanations for inactivity during stopover include the need for rest following prolonged flight, muscle repair, reduced digestive capacity, and the short distance remaining to the breeding grounds. *Received 29 June 2003, accepted 23 March 2004.*

Knowledge of stopover biology is critical to our understanding of the population dynamics of migratory birds (Moore et al. 1995). One area of stopover biology where we know little is activity budgets of migrants en route. Simply put, what does a migrant do from the time it arrives at a stopover site until it resumes migration? Activity budgets can reveal how well migrants meet energetic demands in relation to food resources (King 1974), and also may reflect habitat suitability: migrants may devote more time to foraging in habitats where food resources are low. Activity budgets can also reveal behavioral plasticity that may occur during migration, which tells us how adaptable migrants may be during passage (Greenberg 1990, Martin and Karr 1990). How much time a migrant spends foraging, being vigilant, flying, and engaged in other behaviors is therefore important in helping us to understand differences in habitat selection, mass change, vulnerability to predation, and stopover length among individual migrants.

Part of the reason for the lack of information on activity budgets en route stems from the difficulties of observing songbirds for extended periods of time. One way of overcoming this problem is to use radiotelemetry (Williams 1990). We attached transmitters to Summer Tanagers (*Piranga rubra*) to monitor their activity during stopover following spring trans-Gulf migration. We predicted that Summer Tanagers would spend most of their time foraging, since they likely would need to replenish fat stores following trans-Gulf flight (Moore and Kerlinger 1987). We expected that scanning and preening would be the next most common activities, since avoiding predation and feather maintenance are also important aspects of stopover.

METHODS

Research was conducted off the coast of Mississippi, on Horn Island (30° 14′ N, 88° 40′ W). The island is approximately 22 km long and 1 km wide. We recognized four relatively discrete habitat types: pine forest, scrub/shrub, marsh/meadow, and relic dune (see Moore et al. 1990 for descriptions).

We captured 24 Summer Tanagers in mist nets (12 × 2.6 m, 30-mm mesh) and fitted each with a transmitter. Transmitters (Custom Telemetry and Consulting, Watkinsville, Georgia) weighed 1.3–1.4 g, had a range of 1 km, and a lifespan of 7 days. A transmitter was not attached if the weight of the transmitter exceeded 5% of the bird's body weight (Cochran 1980, Aldridge and Brigham 1988). The weight of radioed tanagers ranged from 25.4 to 32.8 g. We attached transmitters to the base of the central tail feathers using cyanoacrylate glue and a small cable tie, and released birds at their place of capture. We tracked tanagers continuously until either migration resumed or the transmitter failed. Here, we analyze only data for the first day of tracking a given bird; tracking time varied from 4 to 11 hr/bird. Each bird, rather than each movement, was treated as a sample unit to avoid the problem of pseudoreplication (Aebischer et al. 1993), since the movements might not be independent of one another.

[1] Dept. of Biological Sciences, Univ. of Southern Mississippi, Hattiesburg, MS 39406, USA.

[2] Current address: Dept. of Biological and Environmental Sciences, Univ. of Tennessee at Chattanooga, Chattanooga, TN 37403, USA.

[3] Corresponding author; e-mail: david-aborn@utc.edu

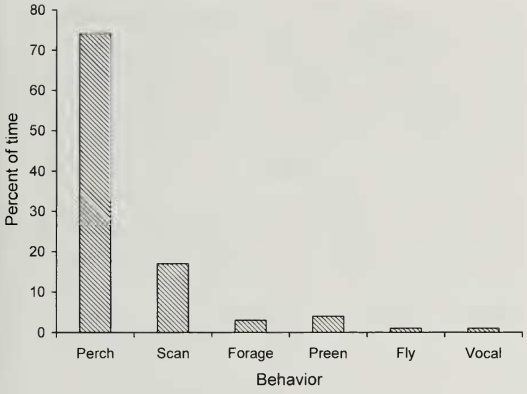

FIG. 1. Activity budgets for all Summer Tanagers on Horn Island, Mississippi while in sight during spring migrations of 1992–1994.

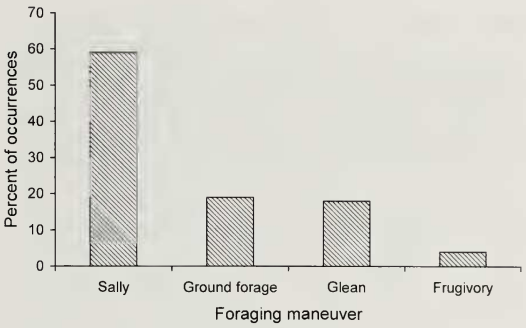

FIG. 2. Foraging methods used by Summer Tanagers on Horn Island, Mississippi during spring migrations of 1992–1994.

We observed activities of tanagers using 10 × 50 binoculars, and dictated observations into a tape recorder for later transcription. Behavioral activities recorded were perching (bird totally inactive), flying (any non-foraging or non-evasive flight), foraging (consuming food), scanning (perched and actively looking around), preening (feather maintenance), aggression (displacing or attacking a conspecific or heterospecific), escape (fleeing or evading a conspecific or heterospecific, including a predator), and vocalizing (singing or calling). Foraging methods (Remsen and Robinson 1990) included gleaning (picking food items from a nearby substrate, excluding the ground, without full extension of the body), sallying (flying from a perch to attack a food item in the air and then returning to the perch), frugivory (consuming fruit), and ground foraging (flying down to or moving along the ground and picking food items). When a tanager was not in view, we categorized the bird as being either perched, active, or flying. For birds classified as "perched," there was no variation in signal strength or direction. For tanagers that were "active," the signal direction fluctuated, but still stayed within a confined area. Based on signal strength, we could tell when birds were within about 50 m, so we knew the bird's movements were localized. Signals of birds that were flying continuously faded in one particular direction, indicating the birds were steadily moving away from the receiver.

To examine the possibility that transmitters might influence tanager behavior, we observed tanagers without transmitters on days when we were not radio-tracking. We recorded the same behaviors as for birds carrying transmitters. We used a chi-square contingency test with a significance level of 0.05 to compare the proportion of time that radio-marked and non-radio-marked tanagers spent in different activities (Zar 1984).

RESULTS

We radio-tracked 24 Summer Tanagers during spring migrations of 1992–1994, for a total of 190 hr. Of total tracking time, 88 hr (45%) were direct visual observations. Visual observations revealed that the birds spent 74% (range: 22–97%) of their time perched (Fig. 1). Scanning, preening, and foraging were, respectively, the next most common activities. Foraging techniques included sallying (59%; range: 0–96%), gleaning and ground foraging combined (37%; range: 0–99%), and frugivory (4%; range: 0–92%) (Fig. 2). Frugivory was low despite an abundance of yaupon (*Ilex vomitoria*) and greenbrier (*Smilax* spp.) berries on the island (J. Clark unpubl. data). Of the prey items we could identify (n = 25), all but one were insects: Lepidoptera (n = 8), Odonata (n = 5), Coleoptera (n = 4), Hymenoptera (n = 4), Orthoptera (n = 2), and Diptera (n = 1). One tanager attempted to eat a green anole (*Anolis carolinensis*; Aborn and Froehlich 1995). The only other activity observed was sleeping. Three birds were observed during daylight hours with their feathers fluffed, eyes closed, and bills tucked into

their backs for 20–40 min each. When not in view, tanagers spent approximately equal amounts of time perched (50%) and active (49%), spending only 1% of the time in flight.

We observed 17 non-radio-marked Summer Tanagers for a total of 54 min. These birds spent 63% of their time perched, 23% scanning, 10% foraging, and 3% flying. Compared with visual observations of all radio-tracked tanagers, there was no significant difference in the proportion of time devoted to the different activities ($\chi^2 = 6.5$, $P = 0.090$). We concluded that transmitters did not influence the behavior of the radioed tanagers.

DISCUSSION

Overall, tanagers spent most of their time perched, with relatively little time spent scanning and foraging. The low percentage of time we observed tanagers foraging contradicts our prediction that the birds would spend much of their time foraging. While information on activity during migration is limited, the foraging time of wood-warblers (Parulidae) during spring migration is reported to be 43–68% (Graber and Graber 1983). During winter, Summer Tanagers are known to perch inactively and then make sudden movements to forage (Isler and Isler 1999). Scarlet Tanagers (*Piranga olivacea*) often exhibit relatively long periods of inactivity while searching for insects during the breeding season (Robinson and Holmes 1982). Thus, low levels of activity may be typical for temperate-breeding tanagers, even during migration.

Inactivity during migratory stopover might reflect the need for rest following trans-Gulf flight. Our observations of tanagers sleeping support this notion. Trans-Gulf migrants must make an 18–24 hr non-stop flight (Moore et al. 1990), which entails loss of an entire night's sleep. Captive Yellow-rumped Warblers (*Dendroica coronata*) induced into spring migratory condition and deprived of one night's sleep showed reduced food handling ability and vigilance compared with warblers that were allowed to sleep (High 1996). Palearctic migrants have also been shown to sleep following trans-Mediterranean flight, which is comparable in flight time and distance to trans-Gulf migration (Schwilch et al. 2002). Schwilch et al. (2002) go on to suggest that sleep is second in importance only to replenishing water and glycogen for migrants that have made long flights. Therefore, spending time resting may increase the likelihood that a migrant will be able to forage efficiently, avoid predation, and successfully complete its migration.

Second, stopover inactivity may be a way of coping with muscle damage. Flight muscle analyses of Horned Larks (*Eremophila alpestris*) that experienced overnight fasting revealed significant depletion of muscle protein and other muscle components (Swain 1992). In particular, sarcoplasm, which is important for muscle contraction, and glycolytic capacity, which is important for intense, short-duration flights were both significantly reduced (Swain 1992). If trans-Gulf migrants experience similar effects, then they may need to allow their bodies to recover from the prolonged exertion. The loss of glycolytic capacity in particular might impair the tanagers' ability to perform foraging maneuvers like sallying.

Third, inactivity may be an effect of reduced digestive function. Experiments with Garden Warblers (*Sylvia borin*) subjected to several nights of fasting revealed that the birds had a reduced metabolic rate, which was attributed to a reduction of digestive function (Klaassen and Biebach 1994). This reduction in digestive function and metabolic rate, in turn, led to reduced activity levels. Taken together, these changes lead to a reduction in energy expenditure that allows migrants to fly greater distances on a given amount of fuel. Trans-Gulf migrants may also experience such reductions, and the lack of activity seen in the tanagers may have been a reflection of this phenomenon.

A fourth explanation for the lack of activity in Summer Tanagers may relate to the remaining distance to the breeding grounds. Many Summer Tanagers breed in Mississippi and Alabama (Robinson 1996), so the birds we observed may have been near the end of their migration and therefore may not have needed to deposit large amounts of fat. Translated into migratory flight distance, tanagers carrying surplus fat have could have flown an average of 513 km (able to reach the Mississippi-Tennessee border), whereas tanagers lacking fat stores could have flown only 162 km (enabling them to reach southern Missis-

sippi) (Pennycuick 1992). Thus, many of the Summer Tanagers stopping on Horn Island may not need to spend much time foraging, and can devote more time to other needs, such as rest or avoiding predation.

On both the breeding and wintering grounds, Summer Tanagers generally use sallying and gleaning to capture insects, primarily Hymenoptera, Orthoptera, and Coleoptera (Robinson 1996, Isler and Isler 1999), largely in agreement with our data. The small amount of frugivory we observed may be typical, as Robinson (1996:6) reports that Summer Tanagers "may take some [fruit] during breeding and migration." Ground foraging is used by Scarlet Tanagers on occasion (Prescott 1965), but has not been recorded previously for Summer Tanagers (Robinson 1996).

Habitats that provide shelter and concealment may be just as important to migrants as habitats that provide adequate food supplies, especially following trans-Gulf flight. Our data further emphasize the need for understanding all aspects of stopover biology in order to adequately conserve migratory landbirds and their stopover sites.

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